



***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

## **Army Robotics**

**07 October 2009**

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**The Future:** Interoperable unmanned systems working hand in hand with Soldiers

- Joint Shared Integrated Picture
- Increased Force Survivability
- Increased Operational Lethality
- Sensors, Shooters, Command, Control & Communications
- Reconnaissance / Surveillance

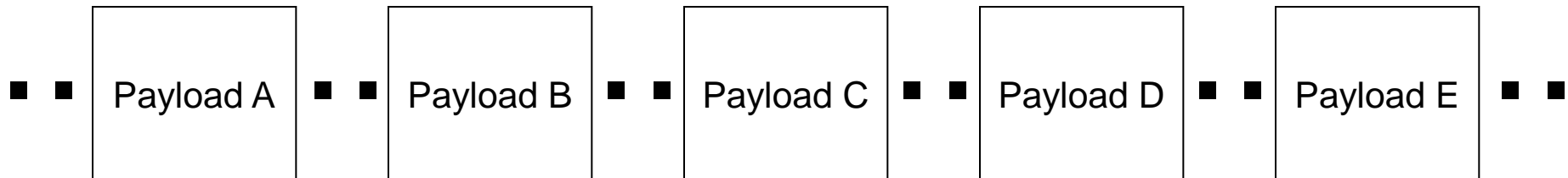
**Today:** Teleoperated, dedicated control unit, COTS systems

Common payload interface across platforms by mission or class

## *Family of unmanned ground systems*



## Payload Interface Standard Architecture



*Mission equipment payloads*

## Maneuver



- IED Defeat Systems
- Disarm / Disrupt
- Reconnaissance
- Investigation
- Explosive Sniffer

## Maneuver Support



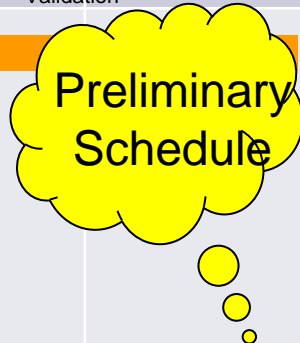
- Area/Route Clearance
- Mine Neutralization
- Counter IED
- CBRNE

## Sustainment



- Common Robotic Kit
- EOD
- Convoy
- Log/Resupply





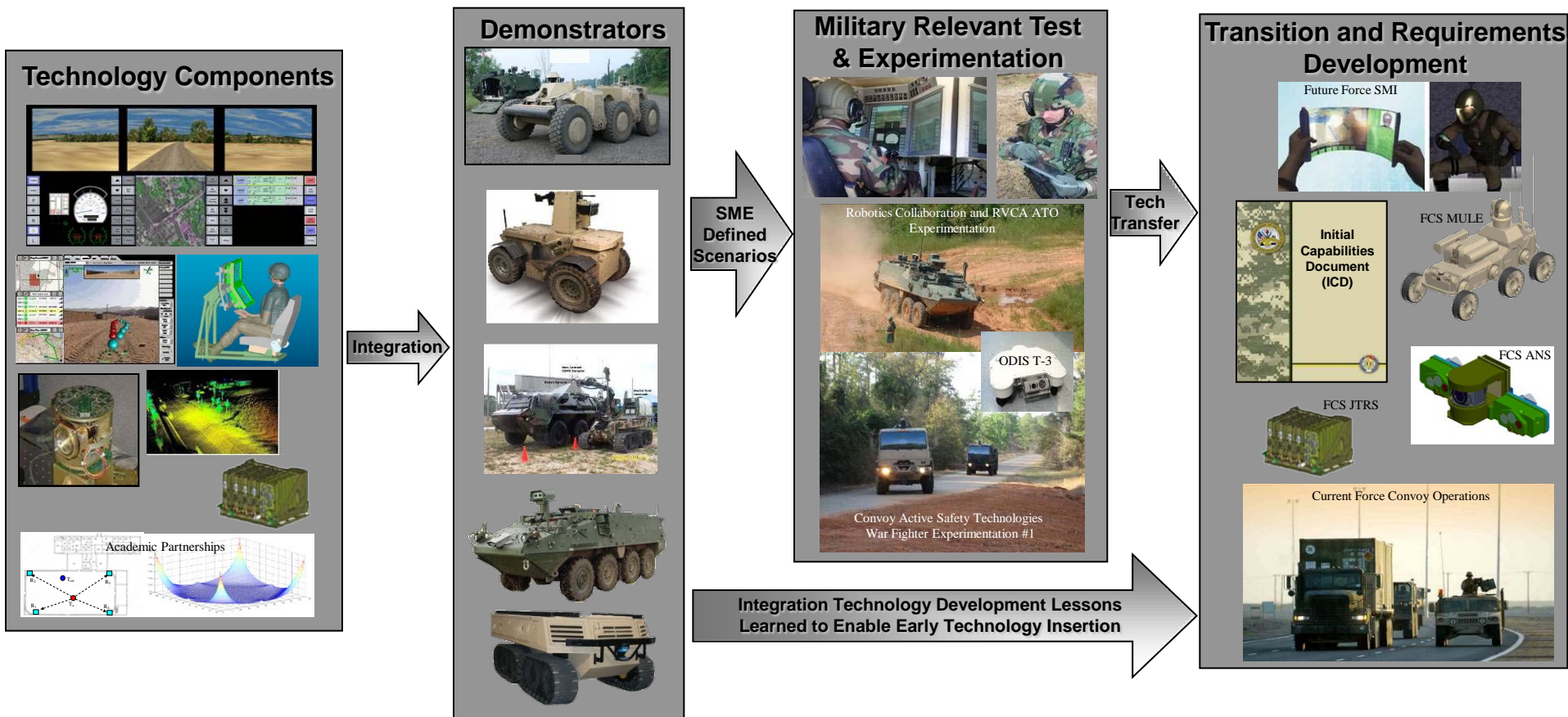
- S&T Support to the RS-JPO
- Develops and Fosters external Relationships
- Matures technology for Insertion into ATO programs
- Robotics Outreach
- RS JPO Collaboration Cell Lead
- Support to IGS Capability Cells
- Robotics Academic Programs (Including Curriculum Development)



Government Partnerships	Industry Partnerships	Academia Partnerships	Community Outreach
	<p>           ABB            BAE            Delphi            Ford            General Dynamics            General Motors            Google            iRobot            JADI            John Deere            Lockheed Martin            Oshkosh            Polaris            QinetiQ            Quantum Signal            Raytheon            SoarTechnology            Think-A-Move            Toyota         </p>	<p>           Auburn University            Carnegie Mellon            Lawrence Technological University            Massachusetts Institute of Technology            Michigan State University            Michigan Technological University            Oakland University            University of Detroit Mercy            University of Michigan – Ann Arbor            University of Michigan - Dearborn            US Military Academy at West Point            Virginia Tech            Wayne State University         </p>	<p> <b>IGVC</b>   <b>FIRST</b>   <b>Robofest</b>   <b>Robotics, Engineering and Technology Days</b>   <b>TARDEC Robotics Quarterlies</b> </p>

## Mission

Integrate, Explore, and Develop Robotics, Network and Control Components with a Focus on Customer Driven Requirements to Provide Full System Solutions to the War Fighter





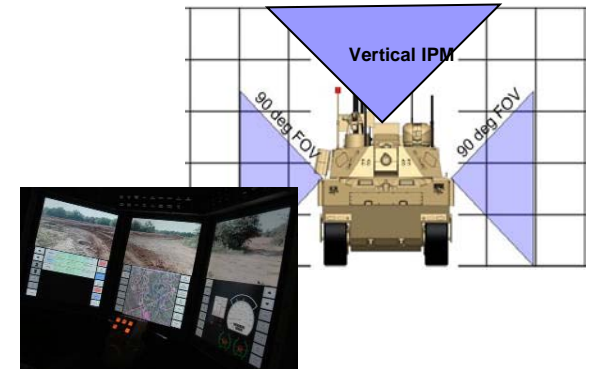
## Autonomous Behaviors



## Warfighter Support



## 360° Situational Awareness



## UGV Safe Operations



## Architecture Development & Demonstration



## Human – Robot Interface





**Near Autonomous Unmanned Systems  
ATO Capstone**



**Robotic Vehicle Control Architecture  
In collaboration with PM-FCS (BCT)**



**Convoy Active Safety Technologies (CAST)**



**Robotics Collaboration ATO Capstone**



## Under Vehicle Inspections



## Remote Mine Detection System



## Construction Engineering Robotic Kit



## Robotic Decontamination





## Autonomous Detection Vehicle

- Autonomous route investigation and hazard marking
- Fundamentally an appliqué kit for Husky
- Funding exists for developmental phase (JIEDDO to NVL)
- Leverage previous work by GDRS for NVL



## Convoy Logistics

- Kit-based system for TWV automated leader-follower
- User assessment at Fort Hood in the September – October timeframe
- Funding exists for developmental phase
  - Potential to leverage JCTD for cycle development



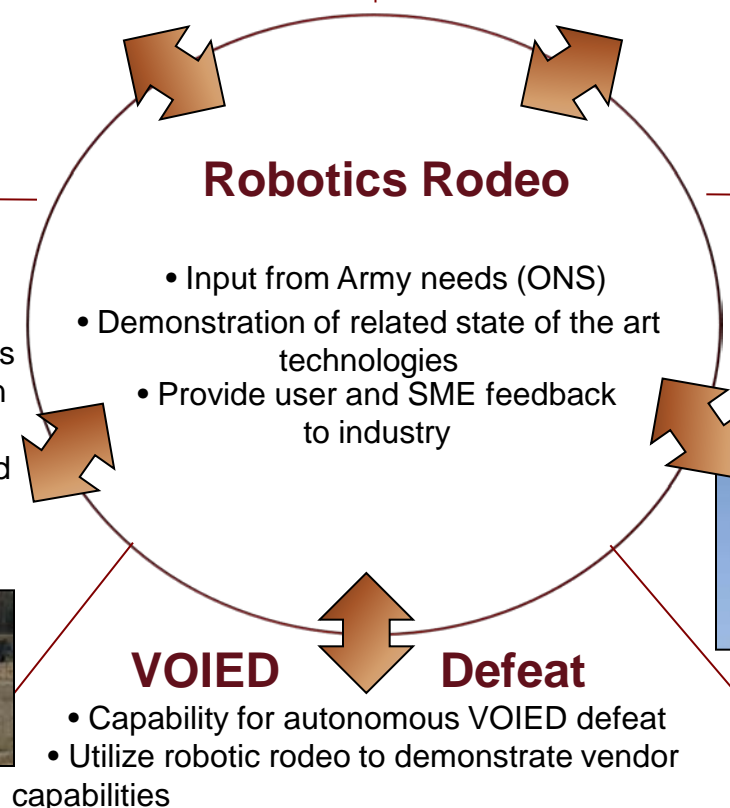
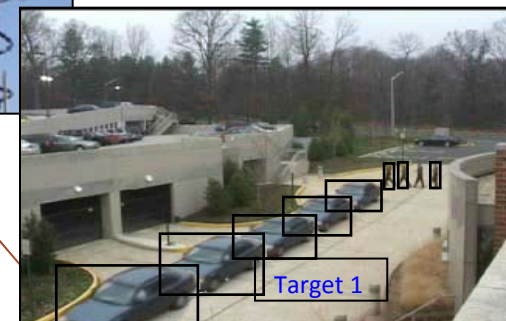
## Manned/Unmanned Teaming (MUT)

- Large armed robotic platform assumes role as a member of squad / formation
- Leverage existing ARDEC, AMREC, CERDEC technologies and Fort Hood rodeo for target acquisition and engagement capability



## Persistent Stare

- Small robot with autonomous navigation to perform recon and surveillance
- Utilize robotic rodeo to demonstrate vendor capabilities



## Robotics Rodeo

- Input from Army needs (ONS)
- Demonstration of related state of the art technologies
- Provide user and SME feedback to industry

## VOIED

## Defeat

- Capability for autonomous VOIED defeat
- Utilize robotic rodeo to demonstrate vendor capabilities





**Robotics CTA – Technology for Near Autonomous Systems**



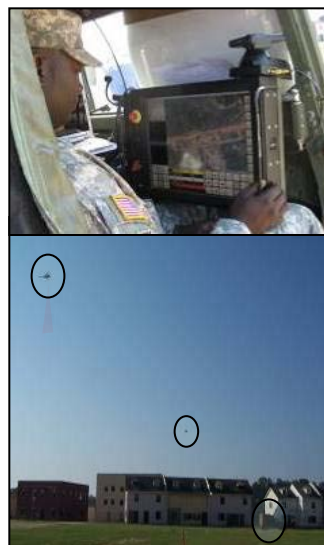
**Robotic Platform for Engineer Missions**



**MAST CTA - Small “Creatures for Urban Terrain”**



**Command & Control of Robotic Entities**



**Air-Ground Collaboration**



**Following, Awareness, SafeOps, and Tracking through IGS (fastIGS)**

## PAST

- Workload reduction
- Embedded crewstation



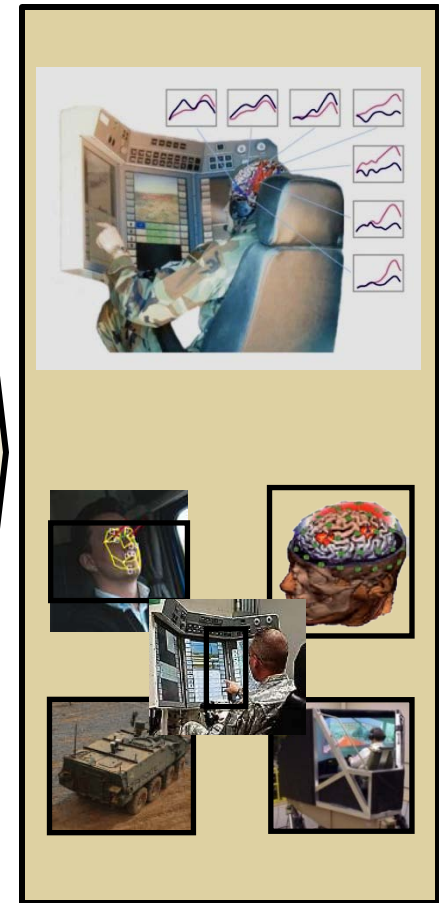
## PRESENT

- Robotic control (mounted, dismounted)
- Driving aids (Soldier assist)
- Scalable, portable Interface



## FUTURE

- Soldier monitoring and task assist
- Intelligent agents
- 360 degree situational awareness





**Purpose:** Incorporate actual hardware both fielded and prototypes using simulation, stimulation and emulation to test concepts and validate capabilities.

- Hardware In The Loop includes:
  - Vehicle Warfighter Machine Interface
  - Dismounted Controllers
  - FBCB2 and other ABCS
  - SoSCOE
  - Autonomous Control Algorithms

## Partners:

- Robotic Systems Joint Project Office (RS-JPO)
- Cross Command Collaboration Effort (3CE)
- Natick Soldier Center – Infantry Warrior Simulation (IWARS)
- Night Vision Labs – Comprehensive Munitions and Sensor Server (CMS2)
- Modeling Architecture for Technology, Research and EXperimentation (MATREX)





*Large*

**Robotics CTA**



*Man-packable*



*Micro*

**Micro-Autonomous Science  
& Technology CTA**



## Consortium Members

- General Dynamics Robotic Systems (Lead Industrial Partner)
- Carnegie Mellon University
- Applied Systems Intelligence
- Jet Propulsion Laboratory
- Alion Science & Technology
- BAE Systems
- Sarnoff Corporation
- SRI International
- Florida A&M University
- University of Maryland
- PercepTek
- Robotic Research
- Signal Systems Corp
- Howard University
- NC A&T University
- University of Pennsylvania
- Skeyes Unlimited
- Johns Hopkins University

## Objectives

*Make the research investments that support the Army's robotic system development goals:*

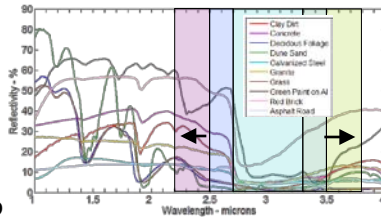
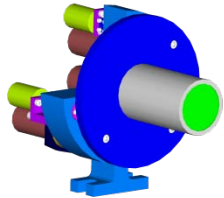
- *Develop perception technologies that allow robotic vehicles to sense and understand their environment;*
- *Develop intelligent control technologies and architectures enabling robotic systems to autonomously plan, execute, and monitor operational tasks undertaken in complex, tactical environments;*
- *Develop human-machine interfaces that allow soldiers to effectively task robotic systems and minimize operator workload.*

## Technical Areas

- Advanced Perception
- Intelligent Control & Behavior Development
- Human / Machine Interfaces



Exploration of novel sensor modes



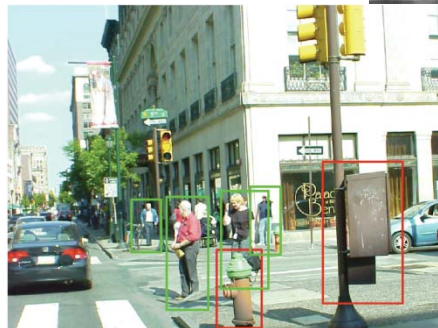
**Novel LADAR**  
**for small systems**    **Spectral LADAR**

...to expand applicability and  
enhance available information

Moving Agent Understanding



*Different postures*



*In clutter & complexity*

Goal is fusion of multiple  
techniques to improve  
accuracy and robustness

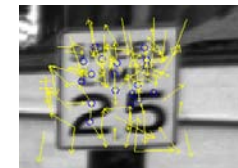
**Improved environmental understanding,  
especially for dynamic environments**

- Application of learning techniques

Terrain Classification



*Topologic  
maps*

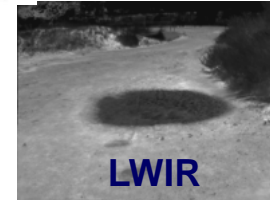


*Road Features*

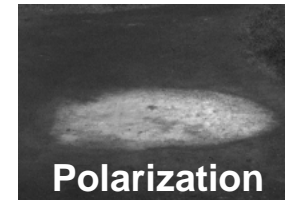
**Sensing Mud**



**RGB**



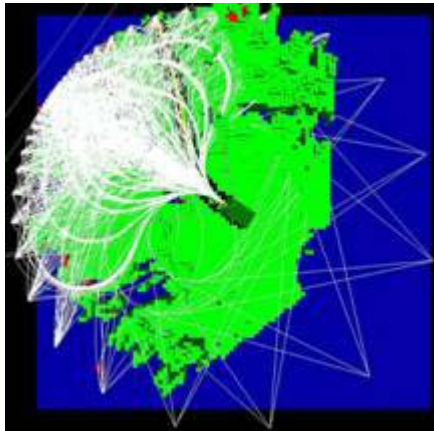
**LWIR**



**Polarization**

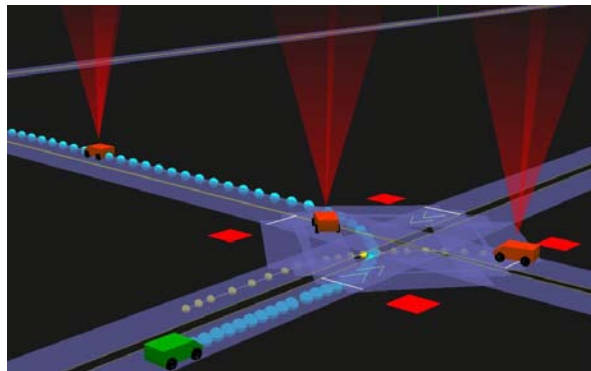
## Examining methods for real-time planning and execution of complex missions

Integration of multiple planners for real-time operation



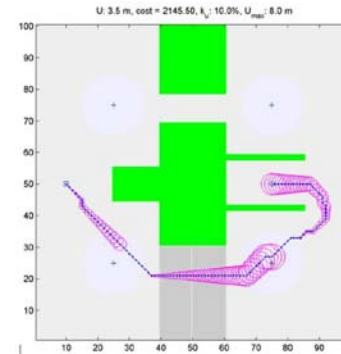
Off-road

High Mobility

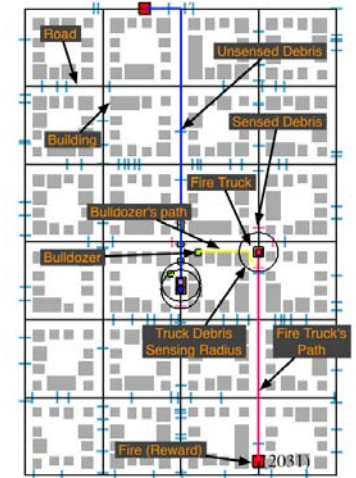


On-road

Planning with uncertainty



...and time constraints



Full implementation of multi-layer planning



  
Dynamic  
Replanning  
Example



## Scalable Human Machine Interfaces



## ...and Multi-Modal Input



... to reduce soldier cognitive workload





### ***Unmanned Systems become another soldier in the unit:***

***highly capable with scalable attributes to meet mission requirements; requiring reduced communication and minimal soldier interaction; flexible, robust, and reliable; able to adapt fully to new & different tactical and environmental conditions; following commanders intent; effectively operating in mixed environments; able to “learn from experience; maneuvering unfettered in complex terrain; able to “live” in a world designed for humans, to grasp small objects, to open doors, or to carry the wounded.***

- ***What missions will they conduct ?***
- ***What level of capability?***
- ***What degree of autonomy will they possess?***
- ***How will they work with soldiers ?***
- ***Or function in general society?***
- ***How will they be used in Urban operations?***
- ***In complex terrain?***
- ***How will they navigate in GPS denied environments ?***



## *Perceive & understand a dynamic & unknown environment*

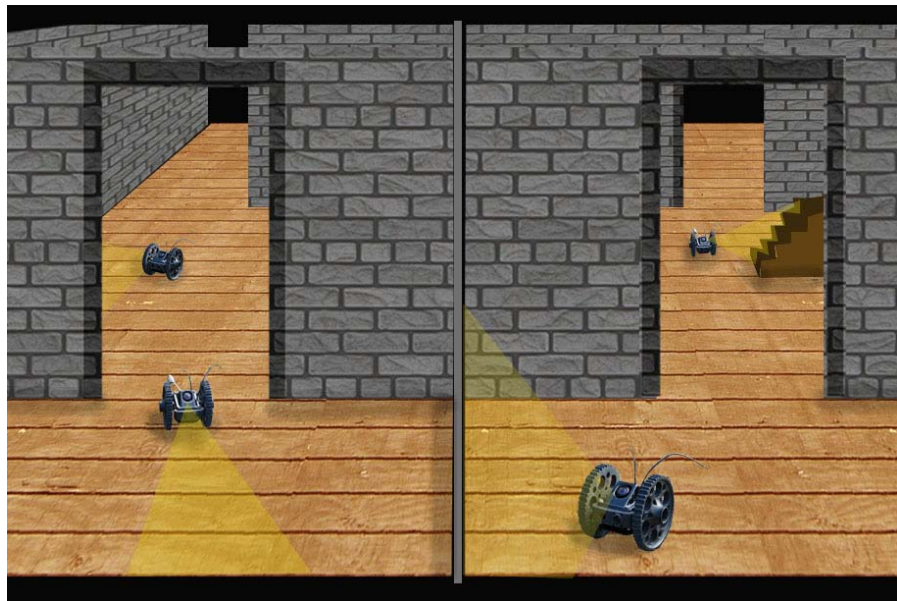


- Sensors
- Information Fusion
- Perception Algorithms
- All environments
- All scales
- Relevant world model

- Sensing
  - Greater resolution & range, lower cost
  - Increased fields of view; focus of attention
  - Scale
  - All weather/environments
- Terrain/Object Understanding
  - Broader vocabulary
  - Recognition of cues/saliency of observations
  - Robust & adaptive
  - Reasoning
  - Fusion
- Understanding activity
  - Human activity/intent recognition
  - Saliency of observations/ context & cues
  - Learning
- World model
  - Managed & validated
  - Long-term & short-term memory
  - Collaborative or distributed
  - Common ground (HRI)
  - Navigation (Intelligence, mobility & manipulation)



## *Plan and execute military tasks & missions*



- Robust
- Adaptive
- Learns from Experience
- Transparent

## *Some potential research topics*

- Learn & Adapt
  - Deductive reasoning
  - Inference
  - Generalization/Rules of engagement
  - Uncertainty of future conditions
  - Probabilistic reasoning
  - Spatial & temporal reasoning
- Self-awareness/introspection
  - Transparency
  - Providing non-verbal cues
  - Human-robot collaboration
  - Fault detection
- World model
  - Common ground
  - Mixed initiative
- Scale
  - Adapting to resource limitations
- Tactically intelligent behavior
- Collaboration between homogeneous & heterogeneous systems

## *Seamless integration of robots into military & civilian activity*



- Effective Control of multiple systems
- Human-robot Teaming
- Seamless integration of robots & society

### *Some potential research topics*

- **Shared situational awareness**
  - Aware of cultural and behavioral norms.
  - Comprehend commander's intent & act upon it
  - Understand the intent of surrounding humans for consideration in planning
  - Possess common spatial & temporal frames of reference – a “common ground”
- **Trust & Confidence**
  - Transparency of action
  - Cues to activity
  - Tolerance to failure
- **Intuitive Communication**
  - Language – unconstrained dialogue
  - Non-verbal cues, gestures, context, & behavior
- **Operating within society**
  - Adaptable to varying social cues & context
- **Span of control**



- ***Unmanned Systems will have a major impact on future military operations***
- ***The technology is still in its nascent stages – the Army has made a firm commitment to its development***
- ***The first systems, albeit teleoperated are already impacting current operations***
- ***The first systems with significant autonomy will be fielded over the next 5 – 10 years***
- ***How the Army employs the technology will, as much as the technology itself, determine its future impact***



